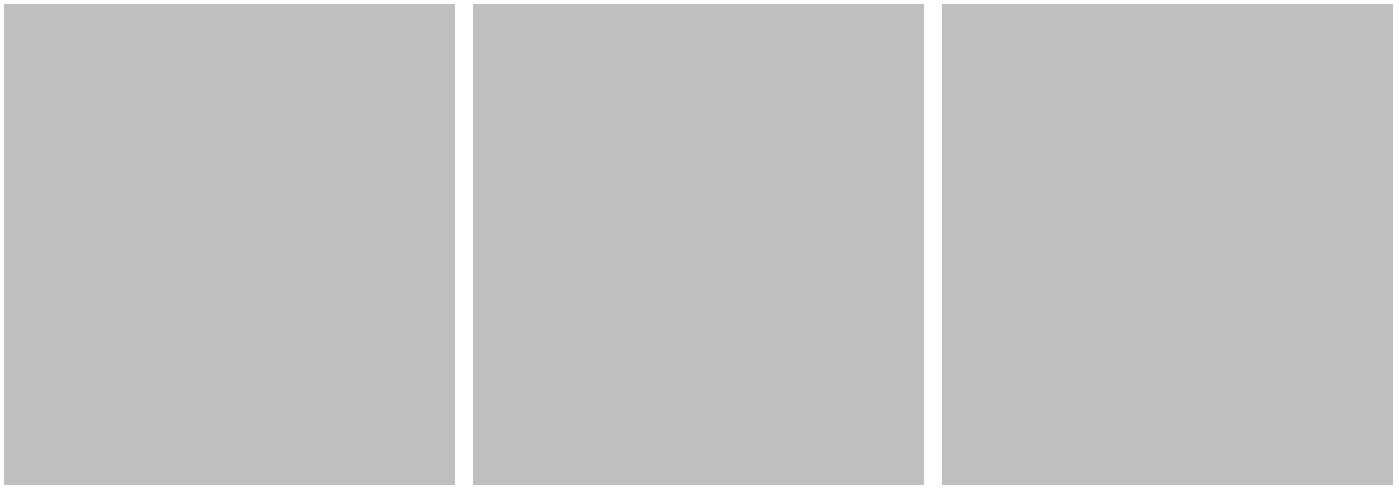
ALLEN–BRADLEY

SLC 500™ RTD/Resistance Input Module

(Catalog Number 1746–NR4)

Product Data



The NR4 enhances the present temperature control capabilities of your SLC 500 system by providing the capability to interface with 12 different RTDs and 4 different direct resistance ranges. RTDs are known for their accuracy, repeatability, linearity and long term stability. The 1746–NR4 / RTD sensor combination is easy to install and provides greater output (ohms/°C or ohms/°F), accuracy, linearity and repeatability with temperature, as compared to other methods of temperature measurement/control. Each NR4 channel accepts different types of RTD inputs (for example, platinum, nickle, copper, and nickle–iron) and accepts resistance devices like potentiometers. The module converts RTD input to temperature (°C, °F) and converts resistance device input to ohms.

The NR4 module provides channel configuration flexibility that allows you to define the operational characteristics for each input channel on the module via your ladder logic programming. There are no hardware DIP switches to set. Each of the module's four channels is configured using your ladder program and may be dynamically reconfigured without handling the hardware. The NR4 performs on–board scaling to engineering units. For example, you can specify RTD or resistance device input, temperature resolution in degrees or tenths of a degree Celsius or Fahrenheit, resistance device resolution in ohms, tenths of an ohm and one–hundredth of an ohm. In addition to engineering units, you can format conversion of the input data to proportional counts or scaled–for–PID.

Features and Benefits

Provides a choice of four filter frequencies, permitting you to select input noise filtering appropriate to the application and surrounding environment. Either or both 50Hz and 60Hz noise can be filtered from the input signal for greater noise rejection and resolution. For applications where system response speed is critical, minimum filtering (250 Hz) can be selected to reduce the time it takes a step change at the input to be made available to the SLC 500 controller.

Requires no user calibration. Each of the module's channels undergoes a calibration cycle at power–up, on channel configuration, or on your command to compensate for module component drift. This enhances module accuracy and saves valuable service time and money.

Provides fault diagnostics to check for open circuits, short circuits or out–of–range values; then indicates operational problems on status LEDs. Channel status LEDs and diagnostic bits signal you if input channel data is out of range or if an open–circuit or short–circuit condition is present. Channel configuration validity is also checked. In addition, a module status LED differentiates recoverable channel errors from more serious module–related problems, saving you troubleshooting time and money.

High Accuracy In A Small Package

Typical module accuracy is 0.05% of full scale for platinum RTDs. In addition, two current sources per channel are user selectable to limit RTD self heating and provide greater system temperature accuracy.

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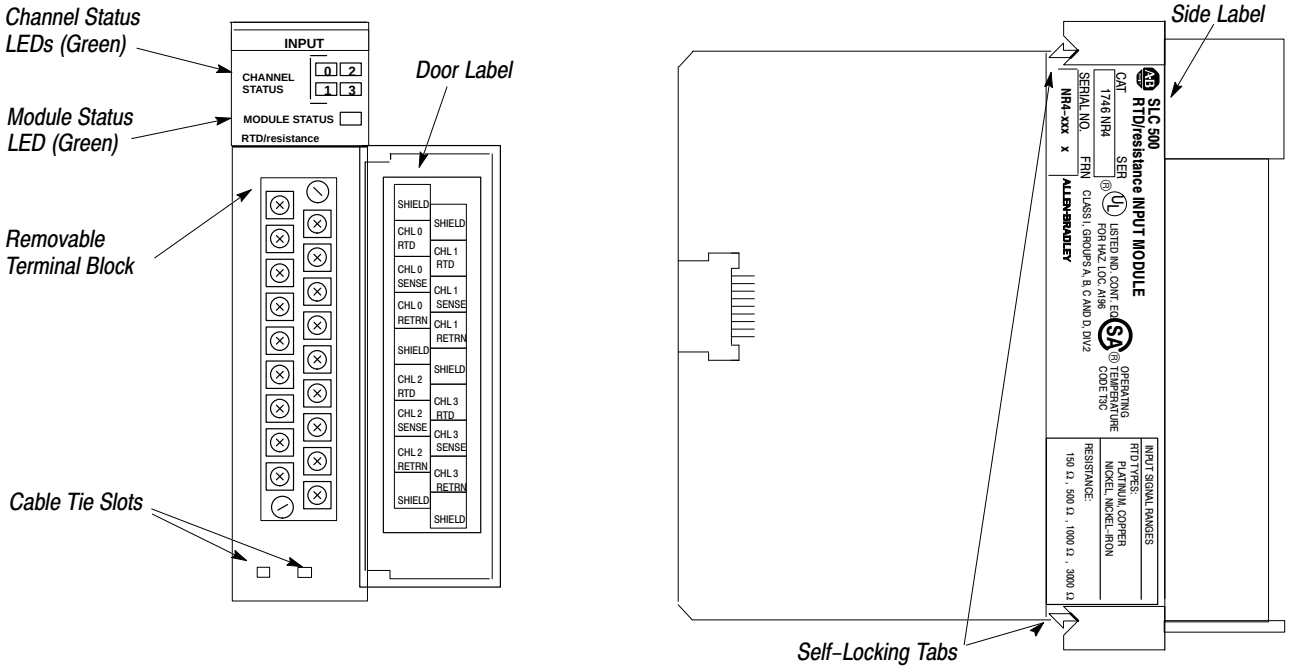
Hardware Overview

The RTD input module fits into any single–slot of an SLC 500 modular system (except the processor slot), or an SLC 500 fixed system expansion chassis. It uses eight input words and eight output words with four inputs multiplexed into an A/D converter. It interfaces with up to 12 RTD types such as platinum, nickle, copper, and nickle–iron, and with resistance devices such as potentiometers.

The module contains a removable terminal block providing connection for any mix of four RTD sensors or resistance input devices. There are no output channels on the module. Module configuration is done via the user program. There are no DIP switches.



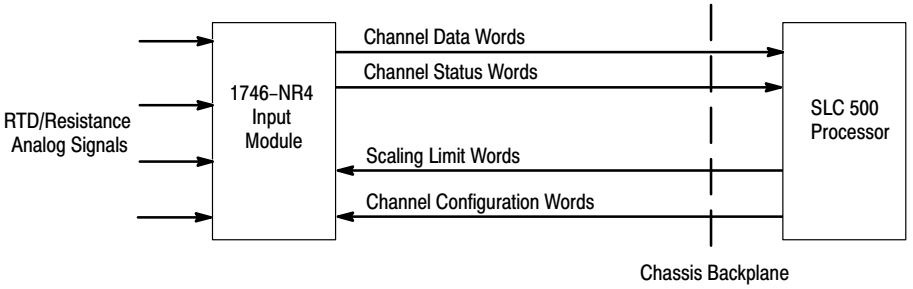
Hardware Features

Hardware	Function
Channel Status LED Indicators	Displays operating and fault status of channels 0, 1, 2, and 3
Module Status LED	Displays module operating and fault status
Side Label (Nameplate)	Provides module information
Removable Terminal Block	Provides physical connection to input devices
Door Label	Permits easy terminal identification
Cable Tie Slots	Secures wiring from module
Self–Locking Tabs	Secures module in chassis slot

Module Operation

At module powerup, a series of internal diagnostic tests is performed. If any diagnostic test fails, the module enters the module error state. If all tests pass, the module initializes its hardware and software environment and turns on the module status LED. During powerup, the RTD module does not communicate with the processor.

After power–up checks are complete, the RTD module waits for valid channel configuration data from your SLC ladder logic program (channel status LEDs off). After configuration data is written to one or more channel configuration words and the respective channel enable bits are set by the user control program, the channel status LEDs go on and the module continuously converts the RTD or resistance input to a value within the range you selected for the enabled channels. The module is now operating in its normal state.



Each time a channel is read by the module, that data value is tested for an under–range, over–range, open–circuit or short circuit condition. If such a condition is detected, an error bit is set in the channel status word and the appropriate channel LED blinks.

The SLC processor reads the converted RTD or resistance data from the module at the end of the program scan, or when commanded by the ladder program. The processor and RTD module determine that the backplane data transfer was made without error, and the data is used in your ladder program.

Calibration

The RTD module is initially calibrated at the factory. The module also has an autocalibration function. Autocalibration compensates for offset and gain drift of the analog circuitry caused by temperature change within the module. When a channel becomes enabled, the module configures the channel and performs the autocalibration on the channel. Each of the module's channels undergoes a calibration cycle at power–up, on channel configuration or on your command via the ladder program. No external, user–supplied device is required for autocalibration.

Compatibility with Controllers and RTD Sensors

The NR4 module is fully compatible with all SLC 500 fixed and modular controllers. It is compatible with all RTDs that conform to the international and local standards shown in the table below:

RTD Type	α①	IEC②	DIN③	D100④	SAMA⑤	JIS (old) ⑥	JIS (new)⑦	Minco⑧
100 Ω Platinum	0.00385	X	X				X	
200 Ω Platinum	0.00385	X	X				X	
500 Ω Platinum	0.00385	X	X				X	
1000 Ω Platinum	0.00385	X	X				X	
100 Ω Platinum	0.03916			X		X		
200 Ω Platinum	0.03916			X		X		
500 Ω Platinum	0.03916			X		X		
1000 Ω Platinum	0.03916			X		X		
10 Ω Copper⑨	0.00426				X			
120 Ω Nickel⑩	0.00618		X					
120 Ω Nickel	0.00672							X
604 Ω Nickel Iron	0.00518							X

① α is the temperature coefficient of resistance which is defined as the resistance change per ohm per °C.
② International Electrotechnical Commission Standard 751–1983
③ German Standard, DIN 43760–1980 and DIN 43760–1987
④ U.S. Standard D100
⑤ Scientific Apparatus Makers Association Standard RC21–4–1966
⑥ Japanese Industrial Standard JIS C1604–1981
⑦ Japanese Standard JIS C1604–1989
⑧ Minco Type 'NA' (Nickle) and Minco Type 'FA' (Nickle–Iron)
⑨ Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.
⑩ Actual value at 0 °C is 100Ω per DIN standard.

Compatibility in a Fixed Expansion Chassis

The 2–slot, SLC 500 fixed I/O expansion chassis supports only specific combinations of modules. The table below summarizes compatibility. Refer to the SLC 500 Family System Overview (Publication Number 1747–2.30) or the RTD/resistance Input Module User's Manual (Publication Number 1746–6.7) for complete compatibility information.

Fixed Chassis Compatibility

The NR4 module cannot be used with these modules:	The NR4 module can be used with this module and an External Power Supply:
OW16	NO4I
OB32	
OV32	

All combinations other than those listed above are valid.

Module Accuracy

The tables on pages 6 and 7 list the RTD types, the associated temperature ranges, and RTD specifications. The table on page 8 lists the resistance ranges for potentiometers and associated specifications.

RTD Temperature Ranges, Resolution, and Repeatability

RTD Type		Temp. Range (0.5 mA Excitation)②	Temp. Range (2.0 mA Excitation))②	Resolution	Repeatability
Platinum (385)①	100Ω	–200 °C to +850 °C (–328 °F to +1562 °F)	–200 °C to +850 °C (–328 °F to +1562 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
	200Ω	–200 °C to +850 °C (–328 °F to +1562 °F)	–200 °C to +850 °C (–328 °F to +1562 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
	500Ω	–200 °C to +850 °C (–328 °F to +1562 °F)	–200 °C to +850 °C (–328 °F to +1562 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
	1000Ω	–200 °C to +850 °C (–328 °F to +1562 °F)	–200 °C to +240 °C (–328 °F to +464 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
Platinum (3916)①	100Ω	–200 °C to +630 °C (–328 °F to +1166°F)	–200 °C to +630 °C (–328 °F to +1166 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
	200Ω	–200 °C to +630 °C (–328 °F to +1166°F)	–200 °C to +630 °C (–328 °F to +1166 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
	500Ω	–200 °C to +630 °C (–328 °F to +1166°F)	–200 °C to +630 °C (–328 °F to +1166 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
	1000Ω	–200 °C to +630 °C (–328 °F to +1166°F)	–200 °C to +230 °C (–328 °F to +446 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
Copper (426)①③	10Ω	Not allowed.⑤	–100 °C to +260 °C (–148 °F to +500 °F)	0.1 °C (0.2 °F)	± 0.2 °C (± 0.4 °F)
Nickel (618)①④	120Ω	–100 °C to +260 °C (–148 °F to +500 °F)	–100 °C to +260 °C (–148 °F to +500 °F)	0.1 °C (0.2 °F)	± 0.1 °C (± 0.2 °F)
Nickel (672)①	120Ω	–80 °C to +260 °C (–112 °F to +500 °F)	–80 °C to +260 °C (–112 °F to +500 °F)	0.1 °C (0.2 °F)	± 0.1 °C (± 0.2 °F)
Nickel Iron (518)①	604Ω	–100 °C to +200 °C (–148 °F to +392 °F)	–100 °C to +200 °C (–148 °F to +392 °F)	0.1 °C (0.2 °F)	± 0.1 °C (± 0.2 °F)

① The digits following the RTD type represent the temperature coefficient of resistance (α), which is defined as the resistance change per ohm per °C. For instance, *Platinum 385* refers to a platinum RTD with α = 0.00385 ohms/ohm –°C or simply 0.00385 /°C.
② The temperature range for the 1000Ω RTD is dependant on the excitation current.
③ Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.
④ Actual value at 0 °C is 100Ω per DIN standard.
⑤ To maximize the relatively small RTD signal, only 2 mA excitation current is allowed.

RTD Accuracy and Temperature Drift Specifications

RTD Type		Accuracy② (0.5 mA Excitation)	Accuracy② (2.0 mA Excitation)	Temperature Drift⑥ (0.5 mA Excitation)	Temperature Drift⑥ (2.0 mA Excitation)
Platinum (385)①	100Ω	± 1.0 °C⑦ (± 2.0 °F)	± 0.5 °C (± 0.9 °F)	± 0.034 °C/°C (± 0.061 °F/°F)	± 0.014 °C/°C (± 0.025 °F/°F)
	200Ω	± 1.0 °C⑦ (± 2.0 °F)	± 0.5 °C (± 0.9 °F)	± 0.034 °C/°C (± 0.061 °F/°F)	± 0.014 °C/°C (± 0.025 °F/°F)
	500Ω	± 0.6 °C (± 1.1 °F)	± 0.5 °C (± 0.9 °F)	± 0.017 °C/°C (± 0.031 °F/°F)	± 0.014 °C/°C (± 0.025 °F/°F)
	1000Ω	± 0.6 °C (± 1.1 °F)	± 0.5 °C (± 0.9 °F)	± 0.017 °C/°C (± 0.031 °F/°F)	± 0.014 °C/°C (± 0.025 °F/°F)
Platinum (3916)①	100Ω	± 1.0 °C⑦ (± 2.0 °F)	± 0.4 °C (± 0.7 °F)	± 0.034 °C/°C (± 0.061 °F/°F)	± 0.011 °C/°C (± 0.020 °F/°F)
	200Ω	± 1.0 °C⑦ (± 2.0 °F)	± 0.4 °C (± 0.7 °F)	± 0.034 °C/°C (± 0.061 °F/°F)	± 0.011 °C/°C (± 0.020 °F/°F)
	500Ω	± 0.5 °C (± 0.9 °F)	± 0.4 °C (± 0.7 °F)	± 0.014 °C/°C (± 0.025 °F/°F)	± 0.011 °C/°C (± 0.020 °F/°F)
	1000Ω	± 0.5 °C (± 0.9 °F)	± 0.4 °C (± 0.7 °F)	± 0.014 °C/°C (± 0.025 °F/°F)	± 0.011 °C/°C (± 0.020 °F/°F)
Copper (426)①③	10Ω	Not allowed.⑤	± 0.6 °C (± 1.1 °F)	Not allowed.⑤	± 0.017 °C/°C (± 0.031 °F/°F)
Nickel (618)①④	120Ω	± 0.2 °C (± 0.4 °F)	± 0.2 °C (± 0.4 °F)	± 0.008 °C/°C (± 0.014 °F/°F)	± 0.008 °C/°C (± 0.014 °F/°F)
Nickel (672)①	120Ω	± 0.2 °C (± 0.4 °F)	± 0.2 °C (± 0.4 °F)	± 0.008 °C/°C (± 0.014 °F/°F)	± 0.008 °C/°C (± 0.014 °F/°F)
Nickel Iron (518)①	604Ω	± 0.3 °C (± 0.5 °F)	± 0.3 °C (± 0.5 °F)	± 0.010 °C/°C (± 0.018 °F/°F)	± 0.010 °C/°C (± 0.018 °F/°F)

① The digits following the RTD type represent the temperature coefficient of resistance (α), which is defined as the resistance change per ohm per °C. For instance, *Platinum 385* refers to a platinum RTD with α = 0.00385 ohms/ohm –°C or simply 0.00385 /°C.

② The accuracy values assume that the module was calibrated within the specified temperature range of 0°C to 60°C (32°F to 140°F).

③ Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.

④ Actual value at 0 °C is 100Ω per DIN standard.

⑤ To maximize the relatively small RTD signal, only 2 mA excitation current is allowed.

⑥ Temperature drift specifications apply to a module that has not been calibrated.

⑦ Module accuracy, using 100Ω or 200Ω platinum RTDs with 0.5 mA excitation current, depends on the following criteria:

(a) Module accuracy is ± 0.6 °C after you apply power to the module or perform an autocalibration at 25 °C ambient with module operating temperature at 25 °C.

(b) Module accuracy is ± (0.6 °C + ΔT × 0.034 °C/°C) after you apply power to the module or perform an autocalibration at 25 °C ambient with the module operating temperature between 0° to 60 °C.

- where ΔT is the temperature difference between the actual operating temperature of the module and 25 °C and 0.034 °C/°C is the temperature drift shown in the table above for 100Ω or 200Ω platinum RTDs.

(c) Module accuracy is ± 1.0 °C after you apply power to the module or perform an autocalibration at 60 °C ambient with module operating temperature at 60 °C.

Resistance Input Specifications

Input Type		Resistance Range (0.5 mA Excitation)	Resistance Range (2.0 mA Excitation)	Accuracy③	Temperature Drift	Resolution	Repeatability
Resistance	150Ω	0 Ω to 150 Ω	0 Ω to 150 Ω	①	②	0.01Ω	± 0.04Ω
	500Ω	0 Ω to 500 Ω	0 Ω to 500 Ω	± 0.5Ω	± 0.014 Ω/°C (± 0.025 Ω/°F)	0.1Ω	± 0.2Ω
	1000Ω	0 Ω to 1000 Ω	0 Ω to 1000 Ω	± 1.0Ω	± 0.029 Ω/°C (± 0.052 Ω/°F)	0.1Ω	± 0.2Ω
	3000Ω	0 Ω to 3000 Ω	0 Ω to 1900 Ω	± 1.5Ω	± 0.043 Ω/°C (± 0.077 Ω/°F)	0.1Ω	± 0.2Ω

① The accuracy for 150Ω is dependant on the excitation current:
± 0.2Ω at 0.5 mA
± 0.15Ω at 2.0 mA

② The temperature drift for 150Ω is dependant on the excitation current:
± 0.006Ω/°C at 0.5 mA
± 0.004Ω at 2.0 mA

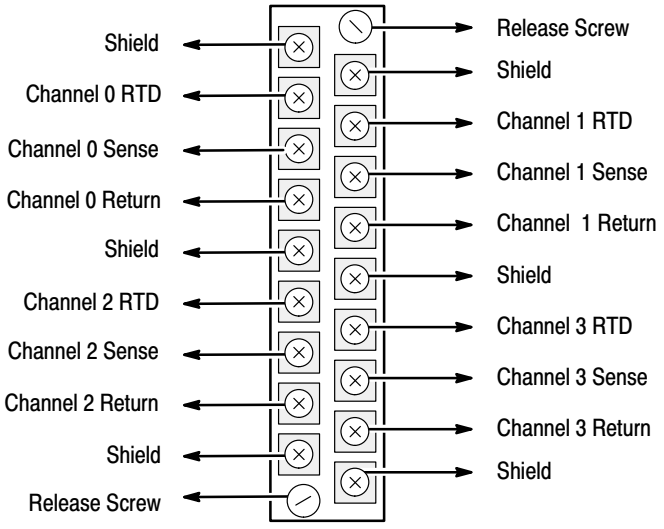
③ The accuracy values assume that the module was calibrated within the specified temperature range of 0°C to 60°C (32°F to 140°F).

Module Wiring

The RTD input module contains an 18–position, removable terminal block.

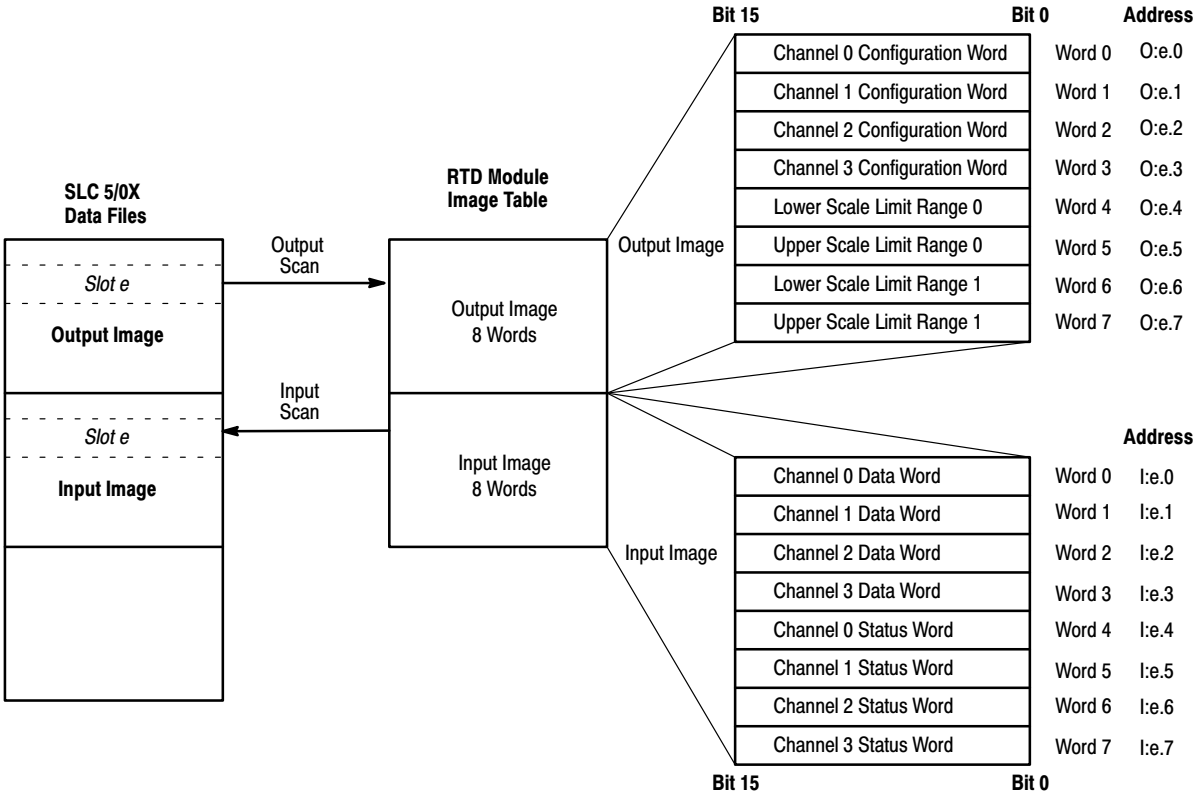
Terminal Block

(Terminal Block Spare Part Catalog Number 1746–RT25G)



Module Addressing

The following memory map shows you how the output and input image tables are defined for the RTD module.



Channel Configuration (Output Image)

Once the module has been installed, each channel on the module can be configured to establish the way the channel will operate. You configure the channel by entering bit values into the configuration word using your programming software. Channels 0–3 on the RTD module are configured by entering bit values into output words 0–3, respectively. Output words 4–7 are used for scaling purposes.

Channel Data and Status (Input Image)

Input words 0–3 (data words) hold the input data that represent the temperature value of RTD analog inputs or the resistance value of resistive inputs for channels 0–3 respectively. This data word is valid only when the channel is enabled and there are no channel errors.

Input words 4–7 (status words) contain the status of channels 0–3, respectively. The status bits for a particular channel reflect the configuration settings that you have entered into the output image configuration word for

that channel, as well as providing information about the channel's operational state. To receive valid status information the channel must be enabled, and the channel must have processed any configuration changes that may have been made to the configuration word.

You can configure the following parameters:

Parameter	Select one of these
RTD Type①	100Ω Platinum (385) 200Ω Platinum (385) 500Ω Platinum RTD (385) 100Ω Platinum RTD (3916) 200Ω Platinum RTD (3916) 500Ω Platinum RTD (3916) 120Ω Nickel RTD (618)② 120Ω Nickel RTD (672) 604Ω Nickel/Iron RTD (518) 1000Ω Platinum RTD (385) 1000Ω Platinum RTD (3916) 10Ω Copper RTD (426)③
Resistance Device Type	150, 500, 1000, or 3000 ohm
Data Format	1.0 degree, 0.1 degrees, 1 ohm, 0.1 ohms, 0.01 ohms, (for 150 ohm range, only) or proportional counts.
Open /Short Circuit	Zero, upscale, or downscale
Temperature Units	°C or °F
Filter Frequency	10 Hz, 50 Hz, 60 Hz, or 250 Hz
RTD Excitation Current	0.5 mA or 2.0 mA
Scaling	Default scaled–for–PID, default proportional counts or user–defined proportional counts

① The digits in parenthesis following the RTD type represent the temperature coefficient of resistance (α) that is defined as the resistance change per ohm per °C. For instance, *Platinum 385* refers to a platinum RTD with α = 0.00385 ohms/ohm –°C or simply 0.00385 /°C.
② Actual value at 0 °C is 100Ω per DIN standard.
③ Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.

The format of the data that the RTD module sends back to the SLC processor depends on how the bits are set in the configuration word. Specific bit fields represent various channel characteristics. Each of these characteristics can be modified from its power–up default setting at any time while the module is operating.

Specific bit settings are discussed in the RTD/resistance Input Module User's Manual (Publication Number 1746–6.7).

The tables on pages 12, 13, and 14 define the data formats and the resolutions that can be represented for each input type.

In these tables:

Engineering Units provide the input value directly in °C, °F, or ohms.

Scaled–for–PID provides a data format directly compatible with the SLC 5/02, SLC 5/03 and SLC 5/04 PID algorithm. Also requires manual conversion to engineering units.

Proportional Counts provide the greatest possible resolution but require manual conversion to engineering units in your control program.

Data Formats for RTD Temperature Ranges Using 0.5 and 2.0 mA Excitation Current

RTD Input Type	Data Format					
	Engineering Units x 1		Engineering Units x 10		Scaled–for–PID	Proportional Counts (Default)
	0.1 °C	0.1 °F	1.0 °C	1.0 °F		
100 Ω Platinum (385)	–2000 to +8500	–3280 to +15620	–200 to +850	–328 to +1562	0 to 16383	–32768 to 32767
200 Ω Platinum (385)	–2000 to +8500	–3280 to +15620	–200 to +850	–328 to +1562	0 to 16383	–32768 to 32767
500 Ω Platinum (385)	–2000 to +8500	–3280 to +15620	–200 to +850	–328 to +1562	0 to 16383	–32768 to 32767
100 Ω Platinum (3916)	–2000 to +6300	–3280 to +11660	–200 to +630	–328 to +1166	0 to 16383	–32768 to 32767
200 Ω Platinum (3916)	–2000 to +6300	–3280 to +11660	–200 to +630	–328 to +1166	0 to 16383	–32768 to 32767
500 Ω Platinum (3916)	–2000 to +6300	–3280 to +11660	–200 to +630	–328 to +1166	0 to 16383	–32768 to 32767
120 Ω Nickel (672)	–800 to +2600	–1120 to +5000	–80 to +260	–112 to +500	0 to 16383	–32768 to 32767
120 Ω Nickel (618)①	–1000 to +2600	–1480 to +5000	–100 to +260	–148 to +500	0 to 16383	–32768 to 32767
604 Ω Nickel Iron (518)	–1000 to +2000	–1480 to +3920	–100 to +200	–148 to +392	0 to 16383	–32768 to 32767

① Actual value at 0 °C is 100Ω per DIN standard.

Data Format for 1000 Ω Platinum RTD (385) Input Type

Excitation Current	Data Format					
	Engineering Units x 1		Engineering Units x 10		Scaled–for–PID	Proportional Counts (Default)
	0.1 °C	0.1 °F	1.0 °C	1.0 °F		
0.5 mA	–2000 to +8500	–3280 to +15620	–200 to +850	–328 to +1562	0 to 16383	–32768 to 32767
2.0 mA	–2000 to +2400	–3280 to +4640	–200 to +240	–328 to +464	0 to 16383	–32768 to 32767

Data Format for 1000 Ω Platinum RTD (3916) Input Type

Excitation Current	Data Format					
	Engineering Units x 1		Engineering Units x 10		Scaled-for-PID	Proportional Counts (Default)
	0.1 °C	0.1 °F	1.0 °C	1.0 °F		
0.5 mA	–2000 to +6300	–3280 to +11660	–200 to +630	–328 to +1166	0 to 16383	–32768 to 32767
2.0 mA	–2000 to +2300	–3280 to +44600	–200 to +230	–328 to +446	0 to 16383	–32768 to 32767

Data Format for 10Ω① Copper (426) RTD Input Type

Excitation Current	Data Format					
	Engineering Units x 1		Engineering Units x 10		Scaled-for-PID	Proportional Counts (Default)
	0.1 °C	0.1 °F	1.0 °C	1.0 °F		
0.5 mA not allowed	---	---	---	---	---	---
2.0 mA	–1000 to +2600	–1480 to +5000	–100 to +260	–148 to +500	0 to 16383	–32768 to 32767

① Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.

Data Format for 150 Ω Resistance Input Type

Resistance Input Type	Data Format			
	Engineering Units x 1	Engineering Units x 10	Scaled-for-PID	Proportional Counts (Default)
	0.01 Ohms①	0.1 Ohms①		
150Ω	0 to 15000	0 to 1500	0 to 16383	–32768 to 32767

① When ohms are selected, the temperature–units selection (bit 8) is ignored.

Data Format for 500Ω, and 1000Ω Resistance Input Types

Resistance Input Type	Data Format			
	Engineering Units x 1	Engineering Units x 10	Scaled-for-PID	Proportional Counts (Default)
	0.1 Ohms①	1.0 Ohms①		
500Ω	0 to 5000	0 to 500	0 to 16383	–32768 to 32767
1000Ω	0 to 10000	0 to 1000	0 to 16383	–32768 to 32767

① When ohms are selected, the temperature–units selection (bit 8) is ignored.

Data Format for 3000Ω Resistance Input Type

Excitation Current	Data Format			
	Engineering Units x 1	Engineering Units x 10	Scaled-for-PID	Proportional Counts (Default)
	0.1 Ohms①	1.0 Ohms①		
0.5 mA	0 to 30000	0 to 3000	0 to 16383	–32768 to 32767
2.0 mA	0 to 19000	0 to 1900	0 to 16383	–32768 to 32767

① When ohms are selected, the temperature–units selection (bit 8) is ignored.

Channel Data Word Resolution for RTDs

RTD Input Type	Data Format (Bits 4 and 5)①							
	Engineering Units x 1		Engineering Units x 10		Scaled-for-PID		Proportional Counts (Default)	
	° C	° F	° C	° F	° C	° F	° C	° F
100 Ω Platinum 385	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0641 °C/step	0.1154 °F/step	0.0160° C/step	0.0288 °F/step
200 Ω Platinum 385	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0641 °C/step	0.1154 °F/step	0.0160 °C/step	0.0288 °F/step
500 Ω Platinum 385	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0641 °C/step	0.1154 °F/step	0.0160 °C/step	0.0288 °F/step
1000 Ω Platinum 385	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0641 °C/step	0.1154 °F/step	0.0160 °C/step	0.0288 °F/step
100 Ω Platinum 3916	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0507 °C/step	0.0912 °F/step	0.0127 °C/step	0.0228 °F/step
200 Ω Platinum 3916	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0507 °C/step	0.0912 °F/step	0.0127 °C/step	0.0228 °F/step
500 Ω Platinum 3916	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0507 °C/step	0.0912 °F/step	0.0127 °C/step	0.0228 °F/step
1000 Ω Platinum 3916	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0507 °C/step	0.0912 °F/step	0.0127 °C/step	0.0228 °F/step
10 Ω Copper 426	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0220 °C/step	0.0396 °F/step	0.0051 °C/step	0.0099 °F/step
120 Ω Nickel 618②	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0220 °C/step	0.0396 °F/step	0.0051 °C/step	0.0099 °F/step
120 Ω Nickel 672	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0208 °C/step	0.0374 °F/step	0.0052 °C/step	0.0093 °F/step
604 Ω Nickel Iron 518	0.1 °C/step	0.1 °F/step	1 °C/step	1 °F/step	0.0183 °C/step	0.0330 °F/step	0.0046 °C/step	0.0082 °F/step

① When ohms are selected, the temperature-units selection (bit 8) is ignored. Analog input data is the same for either °C or °F selection.

② Actual value at 0 °C is 100Ω per DIN standard.

Channel Data Word Resolution for 150Ω Resistance Input Type

Resistance Input Type	Data Format (Bits 4 and 5)			
	Engineering Units x 1	Engineering Units x 10	Scaled-for-PID	Proportional Counts (Default)
	Ohms	Ohms	Ohms	Ohms
150Ω	0.01Ω / step	0.1 Ω / step	0.0092Ω / step	0.0023Ω / step

Channel Data Word Resolution for 500Ω, 1000Ω, and 3000Ω Resistance Input Types

Resistance Input Type	Data Format (Bits 4 and 5)			
	Engineering Units x 1	Engineering Units x 10	Scaled-for-PID	Proportional Counts (Default)
	Ohms	Ohms	Ohms	Ohms
500Ω	0.1Ω / step	1Ω / step	0.0305Ω / step	0.0076Ω / step
1000Ω	0.1Ω / step	1Ω / step	0.0610Ω / step	0.0153Ω / step
3000Ω	0.1Ω / step	1Ω / step	0.1831Ω / step	0.0458Ω / step

Module Diagnostics

The RTD module performs operations at two levels:

- module level operations
- channel level operations

Module level operations include functions such as power–up configuration and communication with the SLC processor.

Channel level operations describe channel–related functions, such as data conversion and out–of–range or open–circuit or short–circuit (RTDs only) detection.

Internal diagnostics are performed at both levels of operation and any error conditions detected are immediately indicated by the module's LEDs.

Power–Up Diagnostics

At module powerup, a series of internal diagnostic tests is performed. If any diagnostic test fails, the module enters the module error state. If all tests pass, the module initializes its hardware and software environment and turns on the module status LED. During powerup, the RTD module does not communicate with the processor.

Channel Diagnostics

When a channel is enabled (bit 11 = 1), a diagnostic check is performed to see that the channel has been properly configured. In addition the channel is tested for out–of–range, open–circuit, and short–circuit faults on every scan.

A failure of any channel diagnostic test causes the faulted channel status LED to blink. All channel faults are indicated in bits 13–15 of the channel's status word. Channel faults are self–clearing when the fault conditions are corrected, and the channel LED will stop blinking and resume steady illumination when the fault conditions are corrected.

Terms and Abbreviations

The following are definitions of some of the terms and abbreviations used in this document:

A/D – Refers to the analog to digital converter inherent to the RTD/resistance input module. The converter produces a digital value whose magnitude is proportional to the instantaneous magnitude of an analog input signal.

channel – Refers to one of four small–signal analog input interfaces available on the module's terminal block. Each channel is configured for connection to an RTD or potentiometer input device, and has its own diagnostic status word.

common mode rejection ratio – The ratio of a device's differential voltage gain to common mode voltage gain. Expressed in dB, CMRR is a comparative measure of a device's ability to reject interference caused by a voltage common to its input terminals relative to ground.

$CMRR=20\ Log_{10}\ (V1/V2)$

cut–off frequency – The frequency at which the input signal is attenuated 3dB by the digital filter. Frequency components of the input signal below the cut–off frequency are passed with under 3dB of attenuation.

data word – A 16–bit integer that represents the value of the analog input channel. The channel data word is valid only when the channel is enabled and there are no channel errors. When the channel is disabled the channel data word is cleared (0).

dB (decibel) – A logarithmic measure of the ratio of two signal levels.

digital filter – A low–pass noise filter incorporated into the A/D converter. In addition, the digital filter provides high–rejection notches at frequencies that are integral multiples of the filter cut–off frequency. The notches are used for rejecting AC power line noise and higher frequency noise.

effective resolution – The amount of jitter (data variation) that typically occurs in the data word due to the influence of the internal electrical noise in the module.

excitation current – A user–selectable current (0.5 mA and 2.0 mA) that the module sends through the RTD or resistance device to produce an analog signal which the NR4 can process and convert to temperature or to ohms, respectively.

filter frequency – The user–selectable first–notch frequency for the A/D converter's digital filter. The digital filter provides AC power line noise rejection when the first notch is at 10 Hz or at the power line frequency.

LSB (Least Significant Bit) – Refers to a data increment defined as the full scale range divided by the resolution. The LSB bit that represents the smallest value within a string of bits.

normal mode rejection (differential mode rejection) – A logarithmic measure in dB, of a device's ability to reject noise signals between or among circuit signal conductors, but not between equipment grounding conductor or signal reference structure and the signal conductors.

resolution – The smallest detectable change in a measurement, typically expressed in engineering units (for example, 0.1 °C) or as a number of bits. For example, a 12–bit system has 4,096 possible output states. It can, therefore, measure 1 part in 4096.

RTD (Resistance Temperature Detector) – A temperature sensing element with 2, 3 or 4 lead wires. It uses the basic characteristic that electrical resistance of metals increases with temperature. When a small current is applied to the RTD, it creates a voltage that varies with temperature. This voltage is processed and converted by the RTD module into a temperature value.

step response time – This is the time required for the A/D input signal to reach *100%* of its expected final value, given a large step change in the input signal.

Specifications

Electrical Specifications

Backplane Current Consumption	50 mA at 5 VDC 50 mA at 24 VDC
Backplane Power Consumption	1.5W maximum (0.3 W @ 5 VDC, 1.2 W @ 24 VDC)
External Power Supply Requirements	None
Number of Channels	4 (backplane isolated)
I/O Chassis Location	Any I/O module slot except slot 0
A/D Conversion Method	Sigma–Delta Modulation
Input Filtering	Low pass digital filter with programmable notch (filter) frequencies
Common Mode Rejection (between inputs and chassis ground)	> 150 dB at 50 Hz (10 Hz and 50 Hz filter frequencies) > 150 dB at 60 Hz (10 Hz and 60 Hz filter frequencies)
Normal Mode Rejection (between [+] input and [–] input)	Greater than 100 dB at 50 Hz (10 Hz, 50 Hz filter frequencies) Greater than 100 dB at 60 Hz (10 Hz, 60 Hz filter frequencies)
Maximum common mode voltage	± 1 volt
Maximum allowed permanent overload①	Volts = ± 5VDC Current= ± 5mA
Input Filter Cut–Off Frequencies	2.62 Hz at 10 Hz filter frequency 13.1 Hz at 50 Hz filter frequency 15.72 Hz at 60 Hz filter frequency 65.5 Hz at 250 Hz filter frequency
Calibration	Module autocalibrates when a channel is enabled or when a change is made to its input type, filter frequency or excitation current.
Isolation (optical)	500 VDC continuous between inputs and chassis ground, and between inputs and backplane
Isolation Between Inputs	None

① Do not apply a voltage or current to the module.

Physical Specifications

LED Indicators	5, green status indicators, one for each of 4 channels and one for module status
Module ID Code	3513
Maximum Termination Wire Size	Two 14 AWG wire per terminal
Maximum Cable Impedance	25 ohms maximum impedance for 3–wire RTD configuration (see Cable Specifications)
Terminal Block	Removable, Allen–Bradley spare part Catalog Number 1746–RT25G

Environmental Specifications

Operating Temperature	0°C to 60°C (32°F to 140°F)
Storage Temperature	–40°C to +85°C (–104°F to +185°F)
Relative Humidity	5% to 95% (without condensation)
Certification	UL listed, CSA approved
Hazardous Environment Classification	Class I, Division 2 Hazardous Environment

Cable Specifications

Description	Belden #9501	Belden #9533	Belden #83503
When used?	For 2–wire RTDs and potentiometers.	For 3–wire RTDs and potentiometers. Short runs less than 100 feet and normal humidity levels.	For 3–wire RTDs and potentiometers. Long runs greater than 100 feet or high humidity levels.
Conductors	2, #24 AWG tinned copper (7× 32)	3, #24 AWG tinned copper (7× 32)	3, #24 AWG tinned copper (7× 32)
Shield	Beldfoil aluminum polyester shield with copper drain wire.	Beldfoil aluminum polyester shield with copper drain wire.	Beldfoil aluminum polyester shield with tinned braid shield.
Insulation	PVC	S–R PVC	Teflon
Jacket	Chrome PVC	Chrome PVC	Red teflon
Agency Approvals	NEC Type CM	NEC Type CM	NEC Art–800, Type CMP
Temperature Rating	80°C	80°C	200°C

Input Specifications

RTD Type: *(Temperature Range Independent of Excitation Current)*	100Ω Platinum RTD (385) –200°C to +850°C (–328°F to +1562°F) 200Ω Platinum RTD (385) –200°C to +850°C (–328°F to +1562°F) 500Ω Platinum RTD (385) –200°C to +850°C (–328°F to +1562°F) 100Ω Platinum RTD (3916) –200°C to +630°C (–328°F to+1166°F) 200Ω Platinum RTD (3916) –200°C to +630°C (–328°F to+1166°F) 500Ω Platinum RTD (3916) –200°C to +630°C (–328°F to+1166°F) 120Ω Nickel RTD (618) ② –100°C to +260°C (–148°F to +500°F) 120Ω Nickel RTD (672) –80°C to +260°C (–112°F to +500°F) 604Ω Nickel/Iron RTD (518) –100°C to +200°C (–148°F to +392°F)
RTD Type: *(Temperature Range Dependent of Excitation Current)*	1000Ω Platinum RTD (385): –200°C to +850°C (–328°F to +1562°F) for **0.5 mA** excitation.① –200°C to +240°C (–328°F to +464°F) for **2.0 mA** excitation. 1000Ω Platinum RTD (3916): –200°C to +630°C (–328°F to+1166°F) for **0.5 mA** excitation. –200°C to +230°C (–328°F to +446°F) for **2.0 mA** excitation. 10Ω Copper RTD (426):③ –100°C to +260°C (–148°F to +500°F) for **2.0 mA** excitation. **Important:** 0.5 mA excitation current *is not* allowed for this RTD.
Resistance Input Types	150Ω for **0.5** and **2.0 mA** excitation. 500Ω for **0.5** and **2.0 mA** excitation. 1000Ω for **0.5** and **2.0 mA** excitation. 3000Ω : **0.5 mA** excitation (0 to 3000Ω) **2.0 mA** excitation (0 to 1900Ω)
Temperature Scale (Selectable)	°C or °F and 0.1°C or 0.1°F
Resistance Scale (Selectable)	1Ω or 0.1Ω for all resistance ranges; or 0.1 or 0.01 Ω for 150 Ω potentiometer.
Input Step Response	See channel step response, page 22.
Input Resolution and Repeatability	See RTD and resistance device compatibility tables on pages 6 and 8.
Display Resolution	See Channel Data Word Resolution tables on page 14.
Module Update Time	See Chapter 4, Update Time, page 22.
Channel Turn–On Time, Reconfiguration Time	Requires up to one module update time *plus* one of the following: • 250 Hz Filter = 388 milliseconds • 60 Hz Filter = 1,300 milliseconds • 50 Hz Filter = 1,540 milliseconds • 10 Hz Filter = 7,300 milliseconds
Channel Turn–Off Time	Requires up to one module update time.
RTD Excitation Current	Two current values are user–selectable: • **0.5 mA** – Recommended for use with higher resistance ranges for both RTDs and direct resistance inputs (1000Ω RTDs and 3000Ω resistance input). Refer to RTD manufacturer for recommendations. *Cannot use for 10Ω Copper RTD.* • **2.0 mA** – Must use for 10Ω Copper RTD. Recommended to use for all other RTD and direct resistance inputs, except 1000Ω RTDs and 3000Ω resistance input ranges are limited. Refer to RTD manufacturer for recommendations.

① Refer to the current recommendations of the RTD manufacturer to determine the best current source for your application.
② Actual value at 0 °C is 100Ω per DIN standard.
③ Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.

Effective Resolution

The effective resolution for an input channel depends upon the filter frequency selected for that channel. The table below provides the effective resolution for the various input types and filter frequencies:

Input Type	Filter Frequency			
	10 Hz	50 Hz	60 Hz	250 Hz
100Ω Pt RTD (385)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.4 °C (±0.7 °F)
200Ω Pt RTD (385)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.4 °C (±0.7 °F)
500Ω Pt RTD (385)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.4 °C (±0.7 °F)
1000Ω Pt RTD (385)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.4 °C (±0.7 °F)
100Ω Pt RTD (3916)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.3 °C (±0.5 °F)
200Ω Pt RTD (3916)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.3 °C (±0.5 °F)
500Ω Pt RTD (3916)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.3 °C (±0.5 °F)
1000Ω Pt RTD (3916)①	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)	±0.2 °C (±0.4 °F)	±0.3 °C (±0.5 °F)
10Ω Cu RTD (426)①②	±0.2 °C (±0.4 °F)	±0.3 °C (±0.5 °F)	±0.3 °C (±0.5 °F)	±0.4 °C (±0.7 °F)
120Ω Ni RTD (618)①③	±0.1 °C (±0.2 °F)	±0.1 °C (±0.2 °F)	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)
120Ω Ni RTD (672)①	±0.1 °C (±0.2 °F)	±0.1 °C (±0.2 °F)	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)
604Ω NiFe RTD (518)①	±0.1 °C (±0.2 °F)	±0.1 °C (±0.2 °F)	±0.1 °C (±0.2 °F)	±0.2 °C (±0.4 °F)
150Ω Resistance Input	±0.02 Ω	±0.04 Ω	±0.04 Ω	±0.08 Ω
500Ω Resistance Input	±0.1 Ω	±0.2 Ω	±0.2 Ω	±0.4 Ω
1000Ω Resistance Input	±0.2 Ω	±0.3 Ω	±0.3 Ω	±0.5 Ω
3000Ω Resistance Input	±0.2 Ω	±0.3 Ω	±0.3 Ω	±0.5 Ω

① The digits following the RTD type represent the temperature coefficient of resistance (α), which is defined as the resistance change per ohm per °C. For instance, *Platinum 385* refers to a platinum RTD with α = 0.00385 ohms/ohm –°C or simply 0.00385 /°C.
② Actual value at 0 °C is 9.042Ω per SAMA standard RC21–4–1966.
③ Actual value at 0 °C is 100Ω per DIN standard.

Channel Step Response

The channel filter frequency determines the channel's step response. The step response is the time required for the analog input signal to reach 100% of its expected final value. This means that if an input signal changes faster than the channel step response, a portion of that signal will be attenuated by the channel filter.

The following table shows the available filter frequencies, associated minimum normal mode rejection (NMR), cut–off frequency, and step response for each filter frequency.

Filter Frequency	50Hz NMR	60Hz NMR	Cut–Off Frequency	Step Response
10 Hz	100 dB	100 dB	2.62 Hz	300 ms
50 Hz	100 dB	–	13.1 Hz	60 ms
60 Hz	–	100 dB	15.72 Hz	50 ms
250 Hz	–	–	65.5 Hz	12 ms

Update Time

The RTD module channel update time is defined as the time required for the module to sample and convert (scan) the input signal of an enabled input channel and make the resulting data value available to the SLC processor for update.

Channel scanning always occurs starting with the lowest numbered channel and proceeding to the next highest numbered channel, for example, channel 0 – channel 1 – channel 2 – channel 3 – channel 0 – channel 1, and so forth. Channel scan time is a function of the filter frequency:

Filter Frequency	Channel Scan Time①
10 Hz	305 ms
50 Hz	65 ms
60 Hz	55 ms
250 Hz	17 ms

① The module–scan time is obtained by summing the channel–scan time for each enabled channel. For example, if 3 channels are enabled and the 50 Hz filter is selected, the module–scan time is 3 × 65 ms = 195 ms.

The *fastest module update time* occurs when only one channel with a 250 Hz filter frequency is enabled.

Module Update Time = 17 ms

NOTE: With 3 channels enabled, the module update time is:

3 channels × 17 ms/channel = 51 ms

The *slowest module update time* occurs when four channels, each using a 10 Hz filter frequency, are enabled.

Module Update Time = 4 channels × 305 ms per channel = 1220 ms

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World Headquarters, Allen-Bradley, 1201 South Second Street, Milwaukee, WI 53204 USA, Tel: (1) 414 382-2000 Fax: (1) 414 382-4444

Publication 1746-2.37 — December 1994

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